Technical Report

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4-PI GAMMA IONIZATION CHAMBER DECAY MEASUREMENTS OF FALLOUT SAMPLES FROM OPERATION CASTLE

Research and Development Technical Report USNRDL-TR-147
NS 088-001

13 January 1956

by

W. H. Shipman
J. R. Lai

U.S. NAVAL RADIOLOGICAL DEFENSE LABORATORY
SAN FRANCISCO 24 CALIFORNIA

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ABSTRACT

Certain fallout samples from Operation CASTLE were retained for decay rate measurement. The exponent of the equation $A_t = A_0 t^{-K}$ was evaluated from appropriate log-log plots and found to be in the range 1.1 to 2.03. This range of values is larger than that expected from thermal-neutron fission.

SUMMARY

The Problem

Since fallout is a heterogeneous mixture of individual nuclides each of which has its own decay rate, an experimental determination of the composite decay rate for a fallout sample is necessary. Certain fallout samples were retained from Operation CASTLE and their decay rates measured.

Findings

Most of the values found for the exponent of the usual decay equation exceeded the value normally used in describing thermal-neutron fission of U^{238}.

ADMINISTRATIVE INFORMATION

The work reported is a by-product of gross gamma measurements of certain samples made for Project 2.5a, Operation CASTLE. It was done under Bureau of Ships Project No. NS 088-001, Subtask 11, Technical Objective SR-2, DD Form 613 of 24 May 1955, and NS 081-001, Subtask 4, Technical Objective AW-7, DD Form 613 of 6 October 1955.

INTRODUCTION

During Operation CASTLE, fallout samples were collected from areas immediately adjacent to and 180 miles from the Pacific Proving Grounds. These samples were returned to this laboratory for gamma measurements in a 4-pi high-pressure ionization chamber. A number of samples were retained for periodic measurements of decay rate. This was done to evaluate the range of the exponent in the equation $A_t = A_0 t^{-K}$, where A_t and A_0 are the radioactivities at time t and at zero time respectively. This paper presents the data and the calculated values of the exponent for fallout samples from the first four CASTLE detonations.

EXPERIMENTAL DETAILS

The locations from which the samples were collected are shown in Figs. 1 and 2. One sample of thatch from the roof of a hut on the island of Rongelap was measured. The remainder of the samples received were of two types: gummed paper and polyethylene fallout collectors.[1]

The gummed papers were cut from their cardboard mounts and each folded to fit the bottom of a 100-ml lusteroid centrifuge tube. These tubes were then placed in the gamma ionization chamber and the decay rate measured.

The samples from the polyethylene fallout collectors were centrifuged in preweighed 100-ml lusteroid centrifuge tubes. These tubes were then placed in the gamma ionization chamber and the decay rate measured.

The samples from the polyethylene collectors were centrifuged to separate the liquid from the solid. The liquid volume was measured in a graduated cylinder, acidified with hydrochloric acid, and concentrated by evaporation to a volume of less than 75 ml. The only possible error introduced by the procedure would be the loss of any iodine that may have been present. The weight of the solid was determined on a semi-micrograma tic balance.

TABLE 1
Summary of Gamma Decay Data From Fallout Samples

Shot	Samples: Site Designation[a]	Samples: Type and Size	Period of Decay After Detonation (hr)	Exponent Value, k	Remarks
1	251.07	Solid, 56.08 g	382 to 870 870 to 1395	1.34 1.16	Location shown in Fig. 2
	Thatch from roof of hut		840 to 4873	1.4	From Rongelap Island. No slope change.
2	T_4 108-2	Gummed paper	165 to 550 550 to 1077	1.8 1.3	Cut into 4 sections due to high level of activity.
	A_4 49-1	Gummed paper	165 to 600 600 to 1077	1.6 1.3	Cut into 2 sections because of high level of activity.
	Q_4 114-5	Gummed paper	165 to 500 500 to 1077	1.7 1.4	
	P_4	Gummed paper	165 to 1077	1.5	No slope change
	Q_4 124-7	Gummed paper	165 to 1077	1.4	No slope change
3	250.06	Liquid, 1665 ml	221 to 821	1.54	No slope change
	250.17	Liquid, 515 ml	221 to 821	1.44	No slope change
	250.17	Solid, 2.81 g	244 to 430 430 to 821	2.01 1.47	
	250.17 GP	Gummed paper	315 to 821	1.67	No slope change
	250.18 GP	Gummed paper	315 to 430 430 to 821	1.93 1.43	
	250.18	Liquid, 560 ml	221 to 821	1.43	No slope change
	250.18 GP (buoy)	Gummed paper	315 to 430 430 to 821	2.03 1.40	
4	YAG 39 TC	Liquid, 365 ml	77.5 to 155 155 to 430	1.1 1.4	The ship was approx. 25 mi NW of Aomoen Island (Fox), Bikini Atoll.

(a) See Figs. 1 and 2.

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The activity of the liquid and of the solid was measured separately in the 4-pi gamma high-pressure ionization chamber.[2] The decay was plotted on appropriate log-log paper. The ionization chamber utilized argon gas under a pressure of 600 psi; the ionization current was impressed across a high resistance. The resulting voltage was measured with a vibrating reed electrometer.[2] Its calibration with respect to energy and linearity agreed closely with published values.

RESULTS AND DISCUSSION

The data have been summarized in Table 1 and the exponent values, k, computed for the decay equation. The observed decay curves are plotted in Figs. 3 through 8.

It has been noted* that these data are within a few percent of the gamma decay curves calculated from radiochemical analysis. The values of k for all the samples except two were greater than 1.2.

The range and magnitude of the exponents are greater than those reported from Operation TEAPOT.[3] The exponent values derived from the fallout collected at Operation TEAPOT ranged from 0.9 to 1.3 while the values from CASTLE ranged from 1.1 to 2.03. It is interesting to note that beta decay measurements made on rain water collected at Harvard University[4] after Operation CASTLE gave exponents of the same order of magnitude as those reported here.

Approved by:

E. R. Tompkins

E.R. TOMPKINS
Head, Chemical
Technology Division

For the Scientific Director

* Personal communication from C.F. Miller of this laboratory.

REFERENCES

1. Stetson, R.L., Schuert, E.A., Perkins, W.W., Shirasawa, T.H., and Chan, H.K. Fallout (short title). U.S. Naval Radiological Defense Laboratory, Operation CASTLE, Project 2.5a, Final Report WT-915, January 1956 (CLASSIFIED).

2. Jones, J.W., and Overman, R.T. The Use and Calibration of a 100% Geometry Ion Chamber. Oak Ridge National Laboratory, Atomic Energy Commission Document AECD-2367, 20 March 1948.

3. Stetson, R.L., Shirasawa, T.H., Sandomire, M.M., Baum, S., and Chan, H.K. Fallout (short title). U.S. Naval Radiological Defense Laboratory, Operation TEAPOT, Project 2.5.2. Final Report WT-1154, 1956 (CLASSIFIED).

4. Bell, Carlos G., Jr. Sanitary Engineering Aspects of Long-Range Fallout From Nuclear Detonations. Howard University and Atomic Energy Commission Report NYO-4654, January 1955.

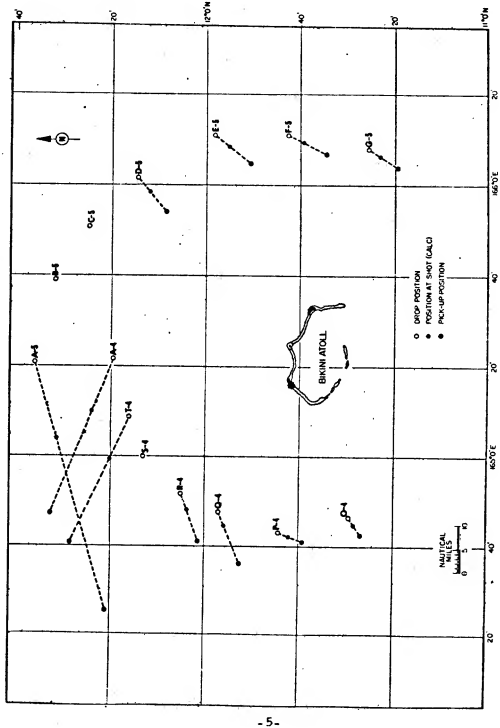

Fig. 1 Sampling Locations for Shot 2, Operation CASTLE
(the Star Marks the Point of Detonation)

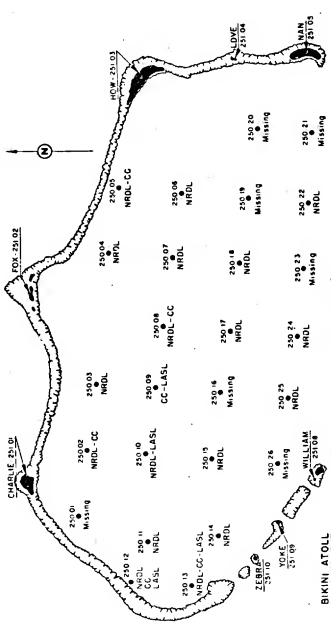

Fig. 2 Sampling Locations for Shot 3, Operation CASTLE

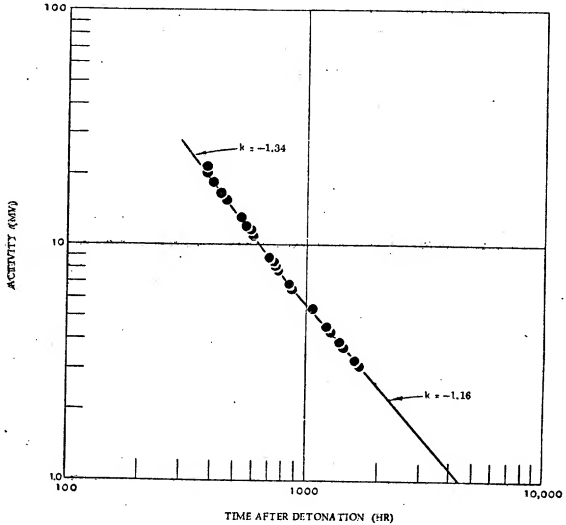

Fig. 3 Gross Decay of Sample 251.07 From Shot 1, Operation CASTLE

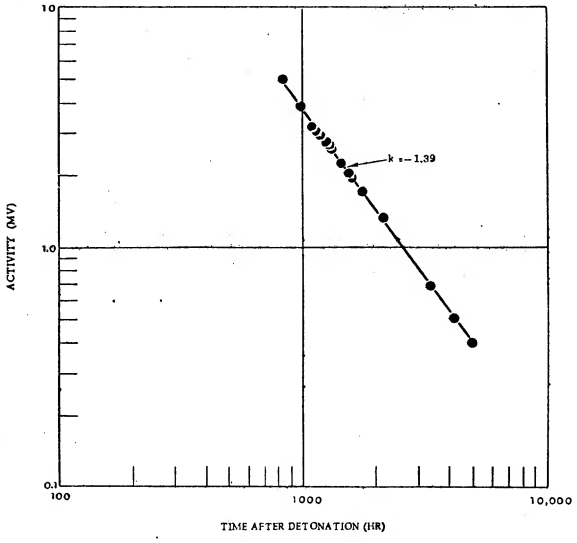

Fig. 4 Gross Decay of Thatch Sample From Shot 1, Operation CASTLE

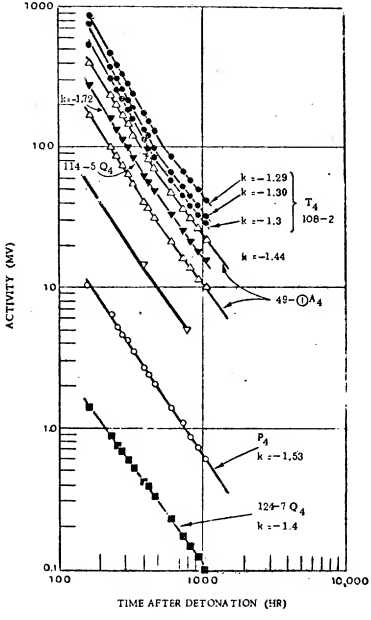

Fig. 5 Gross Decay of Gummed Paper Samples for Shot 2, Operation CASTLE

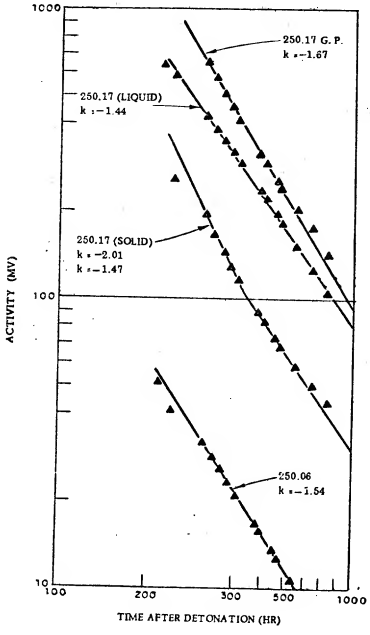

Fig. 6 Gross Decay of Samples From Shot 3, Operation CASTLE

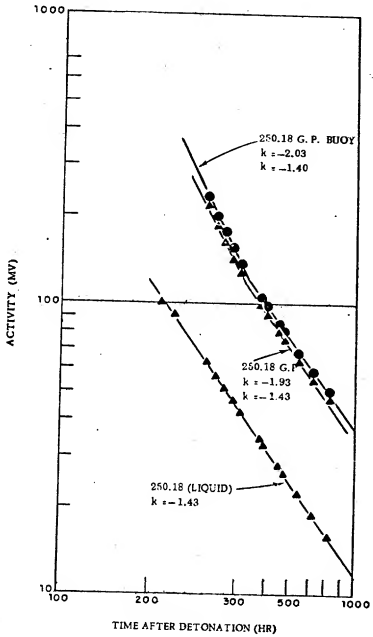

Fig. 7 Gross Decay of Samples From Shot 3, Operation CASTLE

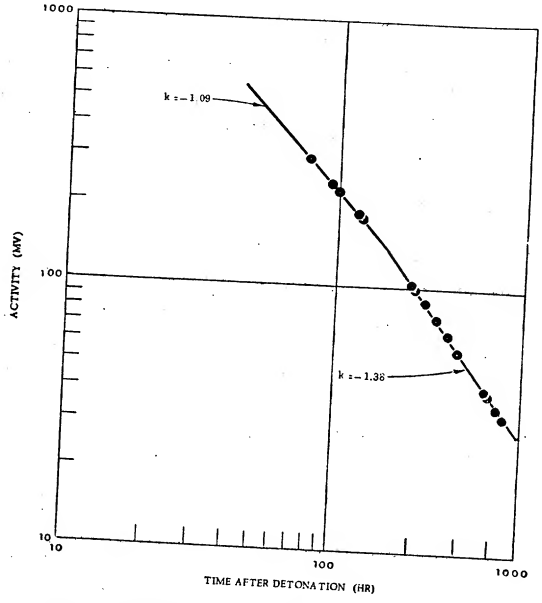

Fig. 8 Gross Decay of Sample 4 YAG-39 TC From Shot 4, Operation CASTLE

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